Activity # 13

Title: Solubility Curves-Teacher's Copy

Note to the teacher:

- (Lab teams of two to three students)
- Each team will be assigned a solute (either table salt or sugar) and also a temperature to maintain throughout the session PRIOR to beginning this activity. Temperatures assigned should range from 30°C to 90°C, all of which are ABOVE room temperature. This will eliminate the need for COOLING the solvent sample to the prescribed temperature.
- If students are not familiar with the use of the Bunsen burner, diagrams and instructions to do so are included with this activity. Hotplates can also be substituted for the Bunsen burners, if available.
- Temperature probes and the Calculator Based Laboratory (CBL) can be incorporated into this activity as a substitute for the thermometer.
- Students will have to be forewarned that if the temperature assigned to their team is exceeded prior to adding the solute, it will take an appreciably lengthy period of time to cool it back down. Due to the "lag" in the thermometer liquid expansion, heating of the water in the beaker should be stopped 10 degrees BELOW the assigned temperature. Once stabilized, the temperature can then be "tweaked" by dancing the burner flame under the wire gauze for a second or two at a time until the desired point is reached. Continue this technique throughout the activity to maintain the assigned temperature to within a Celsius degree or two.
- 50 mL of water is used in this activity (rather than the 100 mL displayed in most solubility curves) to reduce the amount of sugar and table salt required for saturation.
- In small classes you can turn this into a two-day activity by assigning all teams table salt on Day 1 (each with a different temperature to maintain) and sugar on Day 2. This will provide more data for the subsequent graphing exercise.

National Science Education Standards addressed:

Physical Science

CONTENT STANDARD B:
As a result of their activities in grades 5-8, all students should develop an understanding of

Properties and changes of properties in matter

GUIDE TO THE CONTENT STANDARD

Fundamental concepts and principles that underlie this standard include

PROPERTIES AND CHANGES OF PROPERTIES IN MATTER

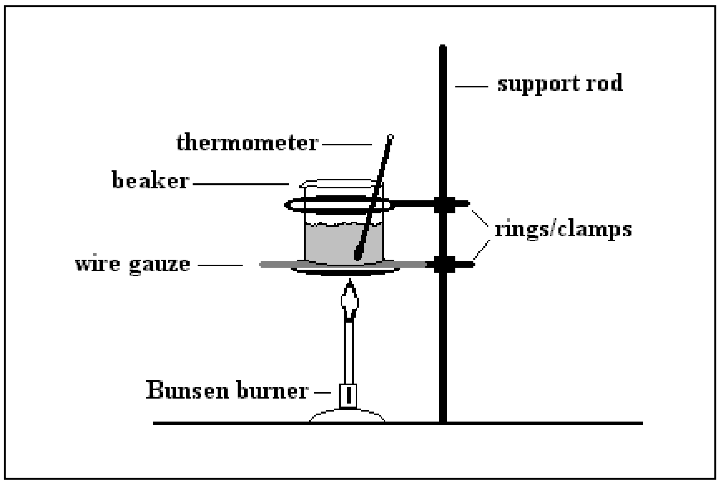
A substance has characteristic properties, such as density, a boiling point, and solubility, all of which are independent of the amount of the sample. A mixture of substances often can be separated into the original substances using one or more of the characteristic properties.

Purpose: to experimentally determine and graphically compare the solubility of various compounds

Materials: beaker, Bunsen burner, burner lighter, stirring rod, laboratory balance, graduated cylinder, weighing dish, Celsius thermometer, 1 solute sample per team (either NaCl or $C_{12}H_{22}O_{11}$), water, wire gauze, 2 rings/clamps, 1 support rod, clamps, chemical scoop, safety goggles, apron

Hazards/Precautions: Because of the use of open flames and heated liquids, long hair will be tied back and safety goggles and aprons will be worn.

Introduction: Each lab team will be assigned the task of determining the number of grams of a specified solute that will be required to produce a saturated solution (using 50 mL of water) at a certain temperature. The entire class's data will be compiled onto a single graph (which each person will include in the laboratory report) for analysis.



Procedure:

1. Pour **exactly 50 mL** of water into the beaker. Assemble your laboratory equipment as shown in the diagram above. (Note the second ring/clamp at the upper region of the beaker for stability!)
2. Heat (Do NOT boil!) the water in your beaker to the specified temperature. This temperature must be maintained throughout the entire activity. (This is one of the tough parts of the lab! Discuss beforehand with your lab team just how you will attempt to **maintain this constant temperature**.)
3. Determine and record the number of grams of your sample solute required to produce a saturated solution at your prescribed temperature. (Uh, oh…. another tough part! A member of your team is going to have to measure, record and tally the series of small solute masses that are added (a little at a time) to the 50 mL sample of water… to the point where no more solute can be dissolved.) Remember to stir the solution continually after each addition of solute.
4. When the saturation point is reached, the heat source can be turned off and the beaker/contents left to cool. Disposal of remaining beaker contents will be at the teacher's direction.
5. Plot the grams of solute dissolved in 100 mL of water on the Y-axis and the temperature in ^{o}C on the X-axis for each solute tested in class as the individual lab teams disclose the results.

Inquiry/Analysis:

1. How did you know when the saturation point was reached with your given sample?

2. If you had recorded the mass of your empty beaker at the beginning of the activity, describe how could you now check the accuracy of your calculated value for "# of grams of dissolved solute" at the specified temperature.

3. Solubility curves are usually expressed as the number of grams of solute that can be dissolved in **100 g** (or mL or cm^3) of water. What needs to be done with OUR solute masses to conform to these standards of reporting? (Remember: we only used 50 mL of water!)

4. After graphical analysis of the entire class's data, a general trend seems to be apparent. Complete the following statement: As the temperature of the solvent (water) increases, the number of grams of solute required to saturate a solution _____________ (increases, decreases, remains the same).

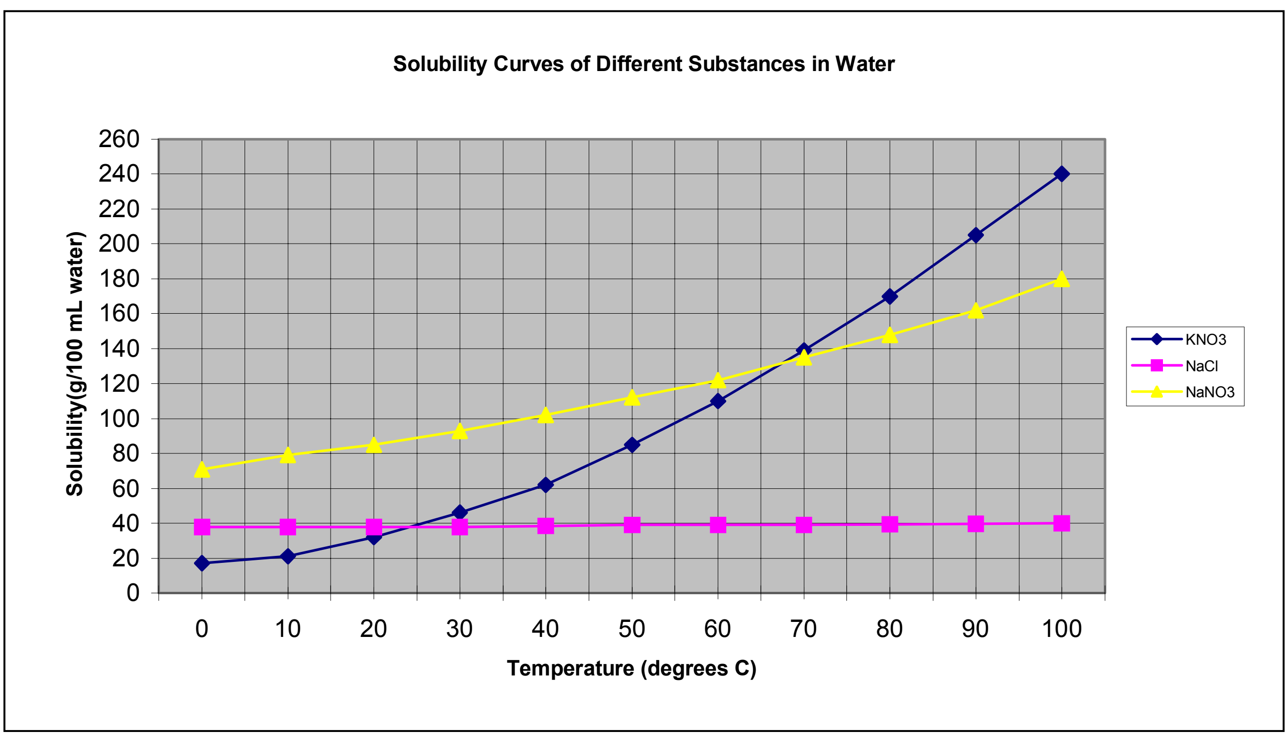
5. Do both solutes appear to be equally soluble in water?

6. What is the independent variable in this activity? (The independent variable is the factor in an experiment that is controlled by the person(s) performing the test.) The independent variable is sometimes referred to as the "manipulated variable."

7. What is the dependent variable on your graph? (The dependent variable is the factor in an experiment that varies as a result of changes made to the independent variable.) The dependent variable is sometimes referred to as the "responding variable" because it responds to changes made to the independent variable.

8. What errors would have been introduced into our lab activity if we were allowed to bring the solvent to a boil?

9. Why couldn't ice be used in an attempt to regulate and maintain a constant water temperature in your beaker during this activity?



10. The solubility of which TWO substances in the graph above is nearly the same at room temperature?
11. If the solution of potassium nitrate was cooled from 100^{oC} to $60^{o}C$, how many grams of solute would you expect to precipitate out of solution?
12. Describe a laboratory separation technique, which could be employed to recover this precipitated solute?
13. After the precipitate was separated (above), describe how you could then recover the remaining dissolved solute (in this same lab period)?
14. If equal samples of each of the saturated solutions above were collected at $45^{o}C$ and then allowed to evaporate to dryness, which would provide the greatest mass of remaining solid?